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AIDATS - CEFLY LANCER DATA LINK COMMONALITY STUDY.(U)
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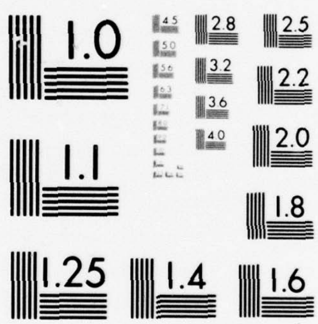

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AIDATS - CEFLY LANCER DATA LINK COMMONALITY STUDY

James E. Bartow
Communications/Automatic Data Processing Laboratory

May 1976

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CEFLY LANCER	Air-Ground Data Link
AIDATS	Cost-effective data link

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

AIDATS and CEFLY LANCER Wide Band Data Link (WBDL) programs and systems are analyzed, and their common features investigated for the purpose of using some CEFLY equipment in the AIDATS program. It is shown that the CEFLY LANCER power amplifier, ground antenna system, and receiver could be employed in the present AIDATS system without impairment of system performance or quality of imagery. An approach is recommended which would prove out the CEFLY LANCER WBDL is an AIDATS configuration. A commonality design, providing a proven design for

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these programs and other requirements could be produced in time to meet future production schedules.

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PURPOSE

The purpose of this study and engineering evaluation effort was to determine a means of introducing a degree of commonality into the design of the wide band data links for the AIDATS and the CEFLY LANCER programs. The method of attack was to determine the feasibility of modifying the procurement of AIDATS hardware to introduce equipments developed for the CEFLY LANCER program. This approach was followed since the CEFLY LANCER engineering development had been completed while the AIDATS engineering development phase was just starting. The overall objective of this effort was to follow the course of action which would result in the most cost effective data link equipment for both programs.

INTRODUCTION

a. The Army Inflight Data Transmission Systems (AIDATS) AN/USQ-49 ( )(V) is an outgrowth of the JIFDATS program which was begun in 1969. After the joint service effort was discontinued in June 1973, it still appeared to hold the best promise of providing a wide band data link for the AN/APS-94 radar in the Army OV-ID Mowhawk aircraft. The Army, therefore continued its portion of the program, hoping to achieve a successful feasibility demonstration of a near-real-time, all weather, day-or-night digital data transmission system as early as possible. The data link requirements for AIDATS include the following:

(1) Must be capable of transmitting imagery without delay from the side-looking airborne radar of the OV-ID directly to the data link ground components. (see Figure 1 and Table I, pages 2 and 3.)

(2) Must transmit the input from the AN/AYA-10 aircraft data annotation system (ADAS).

(3) Must operate at altitudes of up to 25000 ft.

(4) Must be capable of transmitting imagery over ranges of from 1 kilometer up to 150-175 kilometers line-of-sight from the sensor aircraft directly to the ground data terminal.

(5) Must be capable of transmitting either imagery or a beacon signal without breaking lock to ground data terminal during aircraft maneuvers of ±28 degrees roll and ±10 degrees pitch.

(6) Ground components must be capable of cross-country movement along with the tactical units.

(7) Reliability. The MODATS (AIDATS) system shall have a minimum acceptable value of .9 probability of completing a four-hour mission and a best operational capability of .93 probability without a mission failure.

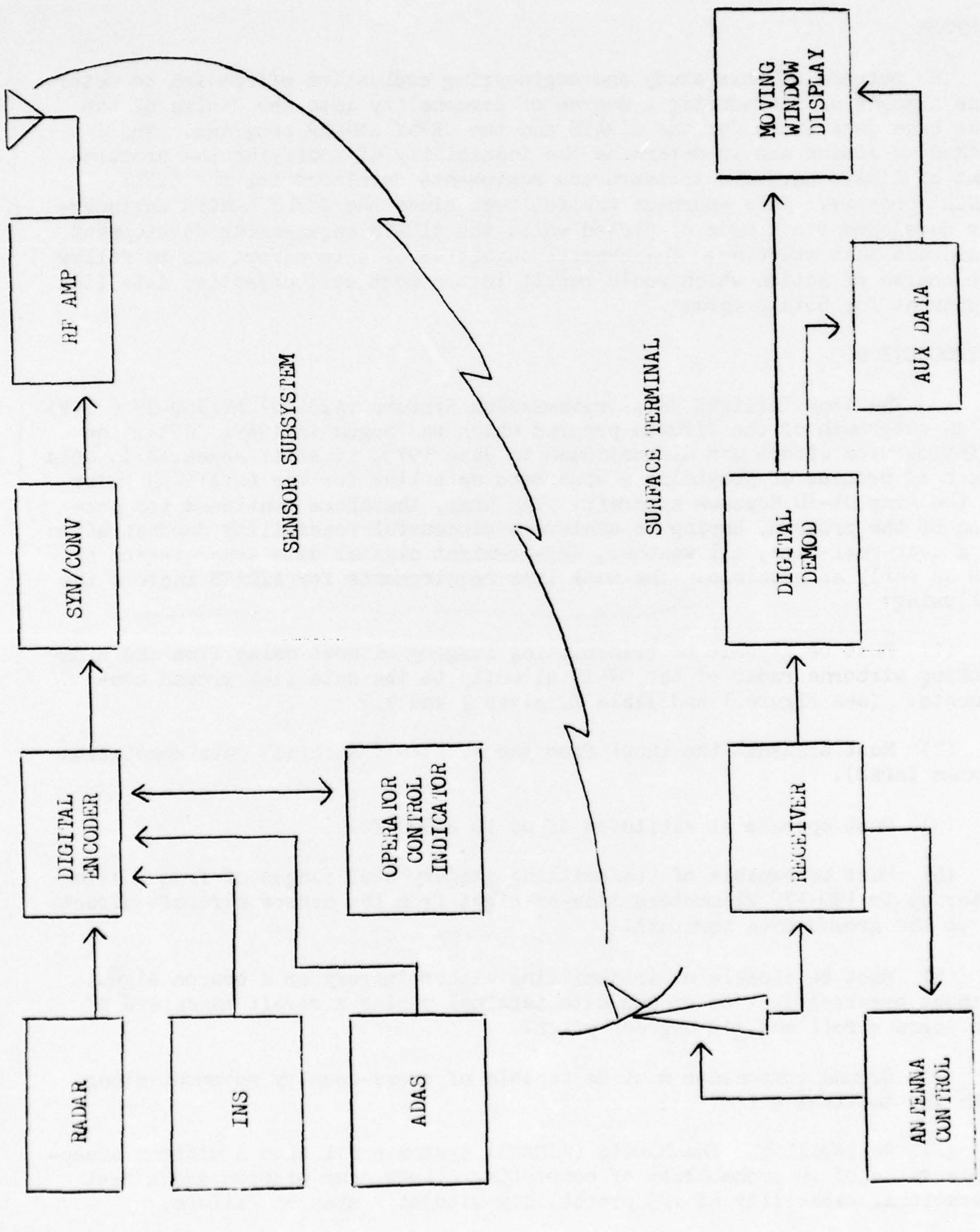


Figure 1. AIDATS Simplified Block Diagram

Table I. AIDATS System Characteristics

MODULATION TYPE	DIGITAL, QPSK
VIDEO BANDWIDTH	6 MHz
RF BANDWIDTH	36 MHz
CARRIER FREQUENCY	J BAND
TRANSMITTER POWER	150 WATTS
MULTIPLE CHANNELS	1 MHz SPACING
DATA RATE	36 Mbs
TRANSMISSION MODES	BEACON: FOR ACQUISITION DATA: FOR INTELLIGENCE
AIRCRAFT ANTENNA	
TYPE	OMNIDIRECTIONAL
GAIN	7 dB
SURFACE ANTENNA	
TYPE	7-FOOT PARABOLOID
GAIN	45 dB
BEAMWIDTH	0.7 DEGREE
RECEIVER NOISE FIGURE	7 dB
TRANSMISSION RANGE	150 km
VIDEO OUTPUT	FILM DISPLAY

The AIDATS data link is a one way air-to-ground system which operates at a bit rate of 36 M bits/sec., uses quadriphase shift keying, operates in J-band, uses an airborne omni-directional antenna and a seven foot paraboloidal reflector, ground tracking antenna system. The antennas are vertically polarized. The ground antenna is mounted on a mobilizer for transport. It uses a pseudo-monopulse tracking technique. A block diagram of the system is shown in Figure 1. The essential system characteristics are shown in Table I.

The AN/USQ-49 consists of two principal subsystems:

Sensor Subsystem: Data Transmission Set, Radio, AN/ASQ-143 ( ) (V)

Surface Terminal: Receiver Processor Central, AN/USQ-50 ( ) (V)

The surface terminal consists of three major units: a Surface Antenna Terminal (SAT), a Surface Recording Terminal (SRT), and a power generator. The SAT is designated as the Converter-Receiver Group, Radio OR-88 ( )(V)URQ. The SAT converts the received J-band frequency to intermediate frequency (1370 MHz) by mixing it with a signal from the frequency synthesizer. The i-f is demodulated to recover the digital data which is processed to generate video signals to reconstruct the imagery and ADAS data.

b. The CEFLY LANCER wide band data link development was started in September 1972 with AEL as the prime contractor. In early 1973 Sperry-Univac was selected as the subcontractor to provide the r-f data transmission equipment including transmitters, receivers, power amplifiers, antennas, frequency synthesizers and related components. Prior to award a comprehensive study of available data links was undertaken to determine if a degree of commonality was possible. The JIFDATS development was reviewed and although it was determined that is was not suitable in its entirety, the CEFLY LANCER specification was patterned after the JIFDATS requirements, especially in the area of ground and airborne tracking antennas. It should be noted that at that time the JIFDATS air-to-ground data link was at C-band. An air-to-air relay at J-band was, however, part of the program.

The CEFLY LANCER wide band data link (WBDL) consists of a command up-link operating at 288 k bits/sec and a wide band down link operating at 3.456 M bits/sec. The aircraft receives commands from the ground station, performs its mission function of intercept and direction finding and transmits the information back to the ground station via the WBDL.

The CEFLY LANCER data link includes the use of an omni-directional as well as two directional (horn) antennas on the aircraft. An antenna control unit allows the automatic selection of antenna and steers the two-axis horns towards the ground station using inverse heading information transmitted up the ground-to-air command link. The transmission range is nominally 150 km, although approximately 15 dB additional margin over the AIDATS system is available with use of the horn antennas. The system requirements include a capability to accept greater bit rates than the 3.456 M bits/sec. of the present CEFLY system. It could easily be modified to accept rates up to 36 M bits/sec. It meets or exceeds all AIDATS requirements as described in the

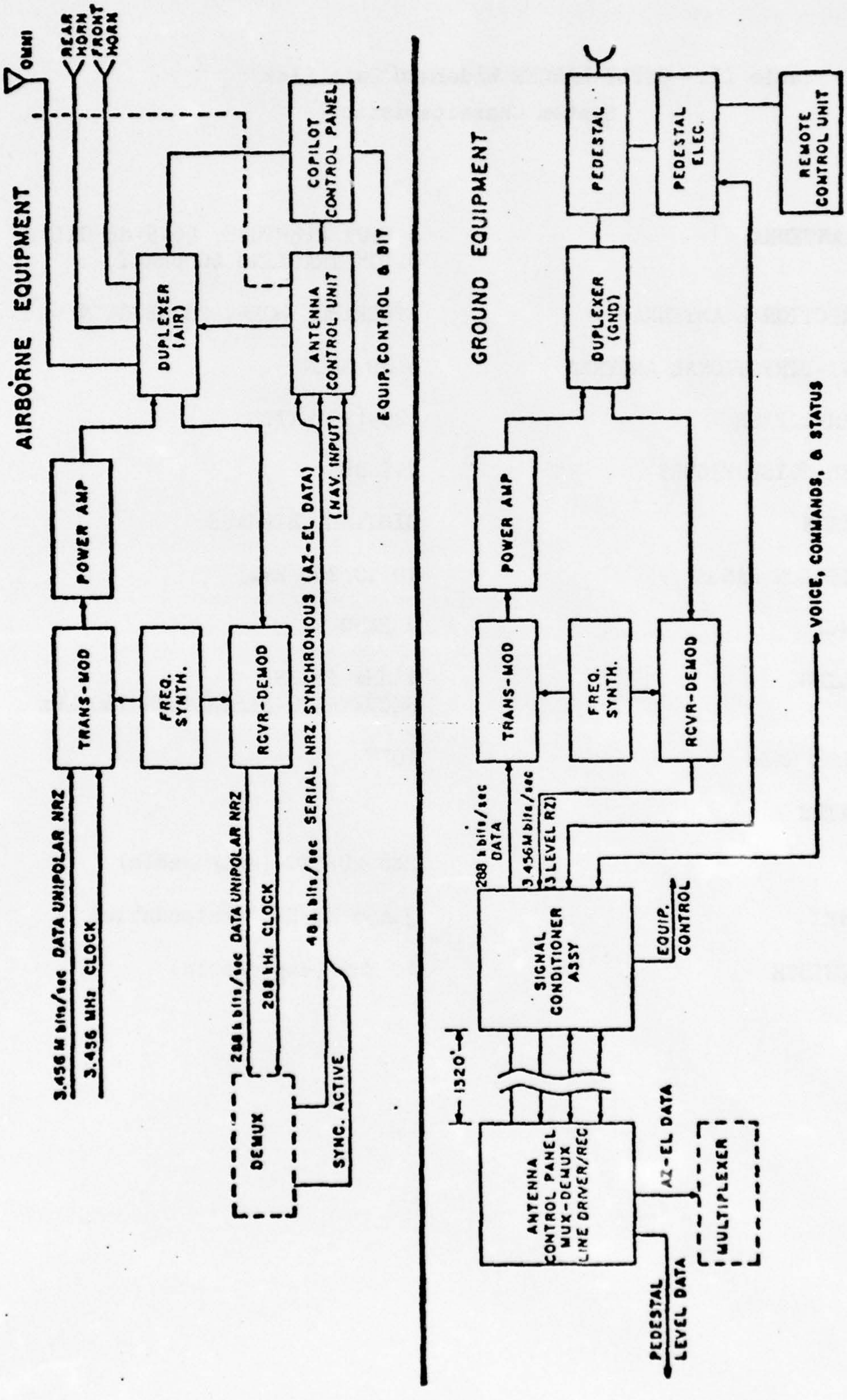


Figure 2. CEFLY LANCER WBDL System Block Diagram

Table II. CEFLY LANCER Wideband Data Link
System Characteristics

GROUND ANTENNA	6-FOOT APERTURE, 46.5 dB GAIN, 0.10° TRACKING ACCURACY
A/C DIRECTIONAL ANTENNA	STEERABLE HORN, 26 dB GAIN
A/C OMNI-DIRECTIONAL ANTENNA	6 dB GAIN
POWER AMPLIFIER	125-150 WATTS
RECEIVER NOISE FIGURE	7.5 dB
MODULATION	DIGITAL, BIPHASE
TRANSMISSION RANGE	10 TO 250 km.
FREQUENCY	J BAND
CHANNELING	1 MHz STEPS RECV/TRANS SEPARATION 160 MHz
BIT ERROR RATE	10^{-6}
DATA RATES	
UPLINK	288 kB/SEC (extendable)
DOWNLINK	3.456 MB/SEC (extendable)
RF BANDWIDTH	10 MHz (expandable)

MODATS ROC (reference 1). A block diagram of the CEFLY LANCER data link is shown in Figure 2. Table 2 lists the essential system characteristics of this data link.

REVIEW OF STUDY EFFORTS

a. This section presents the actions, gathering of information and study effort results which led to the current position and conclusions of this report. The AIDATS/CEFLY LANCER commonality study was started in August 1975 and was completed in February 1976. The following discussion presents in approximate chronological order, each major step in the progress of the study.

b. In July 1975 it was suggested that CEFLY LANCER data link components be used in the AIDATS system. The advantages of the use of CEFLY hardware would be that it was fully qualified, that engineering development was complete, and that a cost saving and reduction in risk were possible results. This subject was discussed with EW Laboratory personnel responsible for the CEFLY LANCER program, CS&TA Laboratory personnel on the AIDATS program and Comm/ADP Laboratory personnel who have acted as technical consultants for the data links on both programs. The Director, CS&TA Lab directed that cost and technical information from Northrop, the AIDATS prime contractor, and Univac, the CEFLY LANCER sub-contractor, for the wide band data link be obtained. This information would be used to assist ECOM in deciding whether to use CEFLY hardware for AIDATS or to continue their planned approach. (Northrop was in the process of starting up an effort to repackage AIDATS components and preparing specifications for a development of a new frequency synthesizer with 1 MHz channel spacing, etc.) The purpose of this effort was to obtain a quote from a second data link supplier with the goal of a possible reduction in cost and risk and the realization of a significant degree of equipment commonality. The restraint under which this effort was to proceed was that there should be no overall delay to the fielding dates (IOC) of the AIDATS or the CEFLY LANCER programs. In order to assure a minimum of disruption of the present AIDATS effort, it was agreed that no more than minor modification to existing AIDATS equipments would be allowed. The components to be supplied must be direct functional replacements for those now developed or proposed for the AIDATS program.

c. Northrop was asked to provide information on their data link costs so that a comparison could be made between their costs and the Univac costs. The specific components of the CEFLY LANCER system which might be directly used in the AIDATS system were defined to supply the necessary cost, schedule, and technical information on the CEFLY LANCER wide band data link. It was agreed that at least the following CEFLY LANCER components were candidates for commonality and should be considered further: power amplifier, omni airborne antenna, ground tracking antenna/pedestal, pedestal electronics and remote control unit. The unit cost for production quantities of 9 airborne and 6 ground stations from Northrop was required as well as cost and schedule impact on the existing Northrop contract were CEFLY data link components to be used. The following descriptions of the CEFLY LANCER equipments were discussed in August with the conclusions as indicated:

(1) Transmitter/Modulator.

The CEFLY LANCER transmitter/modulator accepts digital data at rates of 288kb/sec or 3.456Mb/sec and is designed for expansion in capability to 6.902Mb/sec. The modulator is phase shift keyed (PSK) and the IF frequency is 150 MHz. The Transmitter/Modulator has a Ku band input from the frequency synthesizer at a level of +15 dBm and delivers a modulated Ku band output to the power amplifier at a level of +6 dBm. The present AIDATS approach is to combine the analog to digital converter and modulator into one box. The output of this box is quadriphase modulated i-f signal at 1370 MHz. This signal is fed to a frequency synthesizer/converter which converts it to the output Ku band frequency. The level of the output signal to the power amplifier is -10 dBm. It was concluded that the functions and packaging arrangements of the equipments from the two programs were different to the degree that the CEFLY LANCER transmitter/modulator could not be directly interchanged with AIDATS equipment without some redesign.

(2) Frequency Synthesizer.

The CEFLY LANCER Synthesizer provides an unmodulated signal at Ku band (minus 150 MHz) at a level of +15 dBm to the transmitter/modulator. In addition a second frequency source is included within the same box to provide a local oscillator to the receiver/demodulator. In order to use this equipment for AIDATS, a change in output frequency range is required to provide the difference in i-f offsets, and an up-converter must be added. In addition, the AIDATS requirement is for a single r-f source while CEFLY LANCER provides two r-f sources. In addition, there are differences in frequency stability and residual FM performance. It was concluded that the function, requirements, and packaging arrangements of the frequency synthesizers from the two programs were different, and that these presently designed CEFLY LANCER equipments provide a capability (two channels) in excess of the AIDATS needs.

(3) Power Amplifier.

The CEFLY LANCER power amplifier accepts an input signal of +6 dBm and delivers an output power of 150 watts (+52 dBm). The AIDATS power amplifier includes a driver stage and has an input power of -10 dBm, and output of +52 dBm, with a gain of 67 dB ± 2 dB. The AIDATS power amplifier has a more severe phase linearity and gain variation requirement and a somewhat different air cooling technique.

A proposed approach which would allow the CEFLY LANCER power amplifier to be used for AIDATS is to increase the power output of the AIDATS frequency synthesizer/converter to a +10 dBm level. With this driver level, the equipment will meet all of the AIDATS requirements. This approach was to be investigated further. The power amplifier was considered a candidate for equipment commonality.

(4) Omni Airborne Antenna.

The CEFLY LANCER omni antenna is circular polarized with a gain of 7 dB maximum. The antenna protrudes about 14 inches below the underside of the

aircraft and is enclosed in a radome. The AIDATS omni antenna is vertically polarized with a gain of 7 dB maximum. The antenna will be mounted on an extendable mast 24 inches long from the underside of the OV-1 aircraft. The performance of a similar antenna at a different location and mast length was verified on an OV-1 aircraft by conducting an extensive investigation of pattern measurements. Should an alternate antenna be used, additional tests might be necessary. In addition, the CEFLY LANCER omni antenna is somewhat larger in diameter and might affect the aircraft flight characteristics when extended. It was concluded that introduction of the CEFLY LANCER omni antenna would require additional testing beyond the constraints imposed by the urgent requirement.

(5) Ground Tracking Antenna/Pedestal.

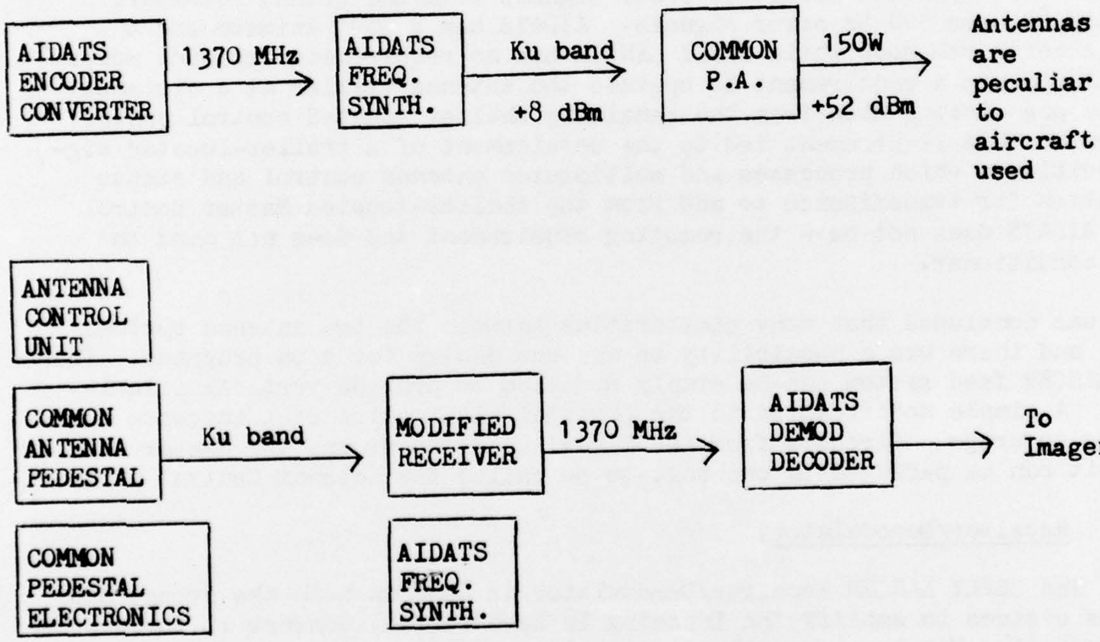
The CEFLY LANCER Ground Tracking antenna uses a circularly polarized fed parabolic dish with conical scanning. Both automatic and manual scanning and tracking modes are available. The AIDATS antenna uses a linearly polarized 7 foot parabolic dish and modified monopulse tracking. AIDATS has 30.8 and 61.6 Hz azimuth and elevation error signals from the ground receiver. CEFLY LANCER uses 500 Hz error signals. AIDATS has a 360° azimuth and a spiral scan search mode while CEFLY LANCER has no requirement for such modes. CEFLY LANCER has a requirement to operate the antenna trailer at a distance of up to one quarter mile from the remaining shelter mounted control center equipment. This requirement led to the development of a trailer-located signal conditioner which processes and multiplexes antenna control and status information for transmission to and from the shelter-located Master Control Unit. AIDATS does not have the remoting requirement and does not need the signal conditioner.

It was concluded that many similarities between the two antenna systems existed and there was a possibility to use one design for both programs. The CEFLY LANCER feed system can be simply modified to provide vertical polarization. A simple modification to the pedestal electronics will increase the scanning coverage. Circuits from the Signal Conditioner and the Master Control Unit can be packaged in one box, to be called the Antenna Control Unit.

(6) Receiver/Demodulator.

The CEFLY LANCER Receiver/Demodulator is used in both the ground and airborne systems to amplify the incoming Ku band signal, convert it to i-f, and detect it. The local oscillator signal is provided from the frequency synthesizer. The AIDATS receiver does not include a demodulator. The output of this receiver is a 1370 MHz i-f signal which is provided to the demodulator, decoder box. It was agreed that the CEFLY LANCER receiver was not identical in function to the AIDATS receiver and would not be considered as a replacement. However, after further discussions with Northrop and further study of the problem, Univac proposed to modify the CEFLY LANCER receiver so that the demodulator circuitry is removed and the output is the 1370 MHz i-f signal. The receiver would have the proper error signals to control the tracking antenna. It would operate with the frequency synthesizer of identical design to the airborne AIDATS frequency synthesizer. In part, the requirements on this equipment would be slightly reduced since an S-band source is required by the present AIDATS receiver but not by the proposed receiver.

d. In September, Northrop provided budgetary unit production costs for the ground tracking antennas, power amplifier, frequency synthesizer/converter and omni antenna. In addition, certain technical requirements of the AIDATS program were provided, which might necessitate modification of the CEFLY LANCER equipment should it be decided to use those equipments in AIDATS. However, information on cost and schedule impact on the current contract quotation were also required in order to make a cost comparison. Univac presented budgetary estimates on 12 Sep 75 for components to be used in AIDATS. These components included the power amplifier, ground antenna pedestal, pedestal electronics, antenna control panal and ground receiver. Univac chose not to consider supplying the omni antenna. Univac submitted costs both for building and modifying existing CEFLY LANCER hardware and for producing the equipment in the quantities required for the AIDATS first buy (9 airborne, 6 ground). Univac submitted a technical proposal which included several options which were discussed in detail. Option 1c was agreed upon as requiring a minimum disruption to the AIDATS program and also requiring the least amount of funds to implement. That option is shown in the following diagram.



The Univac preliminary proposal stated that the power amplifier, antenna pedestal and pedestal electronics would be essentially identical to those used in the CEFLY LANCER program. They proposed to incorporate functions of the CEFLY LANCER Master Control Unit and Signal Conditioner into the Antenna Control Unit and proposed to supply a receiver using a maximum of components from the CEFLY LANCER Receiver/Demodulator, which would interface directly with the AIDATS frequency synthesizer, demodulator decoder and the Univac supplied Antenna Pedestal and Pedestal Electronics. Univac was advised that ECOM would require more information on this approach and on the testing of the equipment and that a firm binding cost quotation was required in order to evaluate the proposal.

Certain technical characteristics of the Univac ground tracking antenna and power amplifier appeared to require modification in order to interface with the AIDATS equipment. These possible modifications include:

(a) error signal frequencies
(b) 360° azimuth search mode
(c) spiral scan search mode
(d) 30°/sec slew rate
(e) back up search mode
(f) BITE circuitry changes
(g) Antenna Control Panel

Univac considered these points and responded that the requirement for modifying the error signal frequencies was appropriate only if the Univac proposed receiver was not used. In that case, the change could be incorporated either in the antenna system or in the receiver. Univac proposed a 180° x 120° window scan size as well as 60° x 12° and 30° x 6°. They indicated that these options provide a reasonable selection of acquisition modes although a further broadening of coverage is possible. Univac stated that their antenna operates at a 30°/sec slew rate and that they have a back up search mode. They will incorporate the BITE circuitry changes and will provide the required antenna control panel incorporating functions of the CEFLY LANCER Signal Conditioner and Master Control Unit. It is necessary that the polarization of the antenna feed be changed from RH circular to vertical. Univac was asked to review the conical scanning technique to insure compatibility with a vertically polarized feed. Univac claimed that the above modifications were minor and that the feed change could be accomplished by a technician in two hours.

There was concern that the CEFLY LANCER power amplifier might not fully meet the AIDATS requirements. Univac reviewed these requirements and claimed that the power amplifier will fully meet the AIDATS requirements by means of tightening some specification tolerances but with no change in design.

Univac proposed to supply manufacturing drawings (category E, form 3), acceptance test plans, and instruction books. They also proposed a 10 week testing period to demonstrate that the modifications and repackaging has accomplished the objectives and met the system requirements. They proposed to fabricate certain components which will be used to modify the existing CEFLY LANCER Antenna Pedestal and Pedestal Electronics. The modified equipment would be tested on a non-interference basis with the CEFLY LANCER program. At the completion of these tests CEFLY LANCER equipments would be restored to their original condition.

The Univac proposal did not fully describe how the CEFLY LANCER components could be bench tested with the equipment to be supplied by Northrop. A further clarification of the Univac proposal was required to cover this and other questions raised. The Univac proposal is based on the frequency synthesizer/converter supplying a power output of +8 dBm to the power amplifier. The present requirement of the AIDATS program is for an output of -10 dBm. The Univac engineers did not feel it would be difficult to incorporate needed circuitry without increasing volume or power requirements in any significant

amount. The circuitry to provide this power output has been developed and qualified on the CEFLY LANCER program. This approach would add to the scope of the proposed Sperry-Clearwater AIDATS Subcontract. However, the Univac receiver design does not require an S-Band input at -10 dBm; therefore, a reduction in complexity will result from the removal of this requirement. Finally, since Sperry-Clearwater was already required to redesign the frequency synthesizer to provide 1 MHz channel spacing, these further changes could easily be incorporated as well.

e. Northrop agreed to conduct an investigation to incorporate certain CEFLY LANCER components into the AIDATS to form a composite Army Data Link, and to prepare a report showing technical differences, scheduling and costs. This proposed effort was to be accomplished without delaying the present AIDATS contractual program. Univac agreed to work with Northrop at a no cost basis to the government in developing the above information.

f. On 16 Oct 75, Univac presented a revised price summary based on the agreed upon Option 1-C. They also presented technical information on tracking antenna polarization, AM resulting from conical scan, documents to be prepared, schedule of manuals and related documents, ground rules, etc. Univac presented an analysis of performance of the AIDATS system, option 1-C, the CEFLY/AIDATS combined system, and other alternative combinations which would provide additional margin. Univac pointed out the limitations of the AIDATS system, including the inferiority of the quadraphase modulator as compared with biphase. This concern about performance led to the preparation of a memorandum on Performance of the AIDATS System, dated 23 Oct 75 (ref. 2). This memorandum showed that AIDATS fell short by 7 or 8 dB of the necessary margin to meet the ROC requirements.

g. By November, it was agreed that the data gathering effort should be completed as soon as possible so that a timely decision could be made on whether or not to direct Northrop to use Univac components in the AIDATS system. It was agreed that ECOM must obtain the required AIDATS cost and schedule impact information. It was agreed that additional information was needed on the limits of range of the AIDATS data link under adverse weather conditions. A preliminary report indicated that the AIDATS range would be limited to 53 to 112 km, although the requirement is for a 150 to 175 km range. A more comprehensive report was started and was completed in January 1976 (ref. 3).

h. On 11 Dec 75 Univac submitted a firm price quotation for the data link equipment and associated documentation, manuals, drawings, non-recurring engineering, tooling, etc. The results of the study on the impact of the introduction of CEFLY LANCER into the AIDATS system prior to the first limited production were received in early January 1976. It appeared that considerable disruption to the AIDATS program would result from this action. Sizable costs were envisioned and a considerable schedule delay was predicted.

i. On 20 Jan 76 a "road map" was prepared of proposed army plans to achieve commonality of CEFLY LANCER and AIDATS. Three alternatives were agreed upon. The first alternative, based on a validation of the urgent requirement for AIDATS, was to continue the present AIDATS effort unchanged.

(It was stated that incorporation of CEFLY LANCER components into the AIDATS system could not be accomplished within the presently assumed schedules.) The second alternative, also based on the validation of the urgent requirement, was to continue the AIDATS effort and in addition pursue a parallel effort to develop a common system. A third approach, based on the possibility that the urgent AIDATS requirement is no longer valid, was to close out the present effort and follow a commonality approach to meet all production requirements. It was determined that no attempt would be made to introduce commonality until after completion of the limited production of the AIDATS system.

DISCUSSION OF TECHNICAL DIFFERENCES

The following discussions describe the technical differences and changes required to the CEFLY LANCER data link equipments for the AIDATS application. This information is based on a review of the specifications for the two data links, comments received from and discussions with Northrop and Univac, and analyses performed in the Comm/ADP Lab.

a. Power Amplifier Gain:

(1) The CEFLY power amplifier gain of 50 dB is insufficient for AIDATS. There was concern that 1.8 dB additional gain must be supplied to account for attenuator control range (for TWT and installation variations).

(2) Univac's approach provides a synthesizer/converter with a J-band output similar to CEFLY's. The 8 dBm output will provide 18 dB more power than the present AIDATS approach. This additional power is more than adequate to make up a 15 dB difference between present AIDATS minimum power amplifier gain and CEFLY's.

The CEFLY approach may be more cost effective since two low noise TWT's are required by the AIDATS design to produce 67 ± 2 dB gain as opposed to one for Univac. The alternate of an amplifier in the synthesizer achieves comparable gain with less cost.

b. Power Amplifier Gain Variations:

(1) The CEFLY LANCER power amplifier gain variation specification of 5 dB maximum is excessive for the AIDATS application. Univac intends to tighten this specification for a commonality approach, without requiring redesign.

(2) The CEFLY and the AIDATS power amplifier use the same Varian TWT. Varian has stated they can meet ± .4 dB gain variation without gain compensation. The regulation of the CEFLY TWT power supply is adequate to meet the ± .4 dB gain variation. Same comment is true for effect on group delay (see item #4).

c. Output Power Levels:

(1) The CEFLY power amplifier specification calls for an output of 125W (min) to 185W (max) while the AIDATS power output requirements are 150W (min)

and 225W (max).

(2) Varian is willing to specify minimum tube output power for the CEFLY tube at 170 watts. This will enable the power amplifier to easily match the 150W power output requirement of AIDATS over the entire CEFLY 850 MHz band.

d. Power Amplifier Differential Ground Delay:

(1) This delay (Phase Non-Linearity) was not specified or tested for the CEFLY P.A. and is therefore highly suspect insofar as meeting the stringent AIDATS requirements.

(2) The CEFLY TWT is the exact same type as the AIDATS TWT. TWT vendor has confirmed that the CEFLY tube will meet the 1.5 nano-second differential group delay. This parameter must (and will) be specified and tested for a common system.

e. Power Amplifier Input Connector:

(1) The input connector to the CEFLY LANCER power amplifier is a TNC connector. CEFLY LANCER uses a coaxial cable between the frequency synthesizer and the power amplifier.

(2) There is approximately 6 dB of interface margin built into the CEFLY system. A 0 to 30 dB variable attenuator at the power amplifier input eliminates excessive drive. The interface attenuation has not been significant for the CEFLY application. A coax to waveguide adapter can be used if necessary with less than .5 dB loss.

f. Power Amplifier Cooling:

(1) A thermal analysis of the OV-1 installation, in conjunction with the CEFLY power amplifier must be performed to determine the requirements for RAM air cooling.

(2) The CEFLY power amplifier was tested on an insulated mounting (to reduce conduction cooling to a minimum) at an altitude of 30,000 ft. and a temperature of 71°C according to MIL-STD-810B Method 504 Class 1A. The power amplifier does not require a cold plate, which reduces weight by 9 lbs. The CEFLY design allows operation on the ground or on the bench without special cooling arrangements.

g. Qualification and Acceptance Tests:

(1) Because of the change from a Sperry to a Varian TWT certain previous qualification and acceptance tests must be re-run to meet CEFLY LANCER requirements.

(2) Univac planned no change to the CEFLY power amplifier for the AIDATS proposal. Varian tube was already being incorporated as spare for CEFLY system and will be throughly tested in that system.

h. Flight Test:

(1) The brass board model of the AIDATS power amplifier passed a portion of the MIL-E-5400 tests, and was flight tested during DT/OT-1. The CEFLY power amplifier must be flight tested prior to completion of the engineering development phase.

(2) The CEFLY power amplifier has been subjected to and passed all airborne environmental tests required of CEFLY system. A flight test is planned for the March 15 to April 15 time frame as part of the CEFLY program.

i. Integration and Testing:

(1) The CEFLY power amplifier must be tested in an integration laboratory to determine its operability in the system.

(2) Univac expects the LRU's it proposes for the AIDATS link will require system integration testing. This testing, however, can be reduced in scope to installation and checkout procedure in most cases since the equipment has already been subjected to several integration type laboratory tests. Univac envisions no technical reason that any schedule impact should result.

j. Ground Antenna Acquisition Modes:

(1) The CEFLY ground antenna does not have a wide beam sector or a spiral scan acquisition mode. The absence of this capability may increase acquisition time and decrease the probability of acquisition in many operational cases.

(2) Univac has performed acquisition and tracking flight tests prior to delivery of CEFLY equipment. The acquisition scheme proved satisfactory in all cases as well as tracking accuracy and rate tests. The ground antenna during final stages of acquisition goes into a figure eight (8^{o} x 2^{o}) box scan mode to provide final lock on the target or for reacquisition. The "box 8" approach for reacquisition is more compatible with flight path. The 70 to 90 sec maximum lock up time differential applies only to the modified 180^{o} x 12^{o} window. All standard CEFLY windows are 60 secs max. Univac believes the smaller scan window will be more useful during actual field operation. The smallest window is designed to lock on very weak signals. The CEFLY raster scan acquisition scheme offers less complexity, lower cost and is more compatible with flight path. A very useful automatic side lobe rejection routine is also featured in the acquisition scheme, but not provided in Northrop's acquisition scheme.

k. Ground Antenna Gain:

(1) Antenna gain will be sacrificed with the substitution of the CEFLY LANCER ground antenna (6 foot diameter) for the present unit (7 foot diameter).

(2) The CEFLY specified minimum antenna gain is 46.0 dB at low frequency and 46.5 dB at upper frequency (actual is better than specification) at the

back of the dish feed. The output port measured gain including nutating loss and rotary joint losses is 44.0 dB at lowest frequency and 44.4 dB at highest frequency. The AIDATS specification states their minimum gain is 44.0 dB at the output port, although the actual gain may be 1 dB higher than this.

l. Antenna Polarization:

(1) The AIDATS system uses vertical polarization while CEFLY LANCER uses circular polarization. A loss of 3 dB would result if the linearly polarized transmission were to be received with a circularly polarized antenna. Since it is not desirable to change the aircraft antenna, the Univac ground antenna feed must be changed.

(2) Circular polarization has been incorporated into the CEFLY system. Circular polarization is superior to vertical linear polarization because of lower multipath losses, lower signal loss due to aircraft orientation and lower side lobes. However, if linear polarization is mandatory, Univac can provide this polarization with no mechanical design changes and no extra cost. Changing from circular to linear vertical is a matter of removing a dielectric chip from feed. Nutation does not effect polarization.

m. Tracking Error Signals:

(1) The 30.8 Hz tracking error signal existing in the CEFLY LANCER system is incompatible with the AIDATS receiver which is designed to accomodate a 500 Hz signal.

(2) Univac's proposal includes both the receiver and the tracking antenna; the error signal poses no problem as proposed.

n. Water Fording:

(1) It has been suggested that the CEFLY LANCER pedestal must be redesigned to meet a 72" water fording requirement if mounted on the AIDATS antenna platform. If mounted on the M-390 trailer, the installation, including equipment enclosure, must be modified to accomodate weather and fording.

(2) The CEFLY antenna is designed to meet a 72" water fording requirement for CEFLY. It is also designed to withstand Munsen road test when mounted on M-390 trailer.

o. Trailer/SRT Electrical Interface:

(1) The trailer interface circuits must be modified to match hard wire signal and power cabling to the AIDATS surface recording terminal. The cabling itself must also be modified.

(2) Univac expects that electrical interface will have to be modified. Power and built-in-test wiring will be the primary concern. Connectors and pin assignments will be different. Cable between antenna control unit and pedestal electronics will be part of proposed Univac ground antenna subsystem.

p. Master Control Unit Changes:

(1) The changes to the CEFLY master control unit include:

(a) Removal of digitizing and multiplexing functions (2-3 cards).

(b) Installation of signal conditioner circuitry (5 card, some modified).

(c) Modification of internal harness and removal of unnecessary functions.

(d) Redesign front panel.

(e) Change specs, ICD's, etc.

(f) Change acceptance and environ

(2) CEFLY systems are configured so that antenna control can be located ¼ mile away in order that ground personnel may be protected from enemy attack. The AIDATS requirement is only 250 ft.; therefore, Univac proposes to combine the pertinent contents of the master control and signal conditioner into the master control chassis box and call it the Ground Antenna Control.

It was anticipated by Univac that this would be desired at some future date since the antenna control for other Univac programs has been configured in one box. The change can be made by eliminating multiplexing, demultiplexing and driver circuit cards moving synchro to digital converter cards into the Master Control Unit rack. Harness will have to be redesigned and a few other minor modifications made.

The resulting unit will contain the same circuitry found in the CEFLY system with exception of circuit cards deleted. Univac proposes that the unit can be qualified by similarity to CEFLY hardware configurations. It is believed that the CEFLY type unit will be more cost effective and provide a more up-to-date design because of solid state digital controls and readouts.

q. Ground Antenna Modifications:

(1) Univac has proposed that the ground antenna be built to print with two minor exceptions:

(a) The feed be linearly polarized instead of a circularly polarized one. This entails no change in mechanical design, electrical design or cost.

(b) Univac is confident that the present scan window and acquisition scheme used for CEFLY is adequate, but window scan can be modified by changing raster scan generator printed circuit card if desired.

r. Frequency Synthesizer/Converter (FS/C) Output Connector:

(1) The output connector now planned for the FS/C under development is a waveguide connector. As previously noted the CEFLY LANCER system uses a coaxial cable input to the power amplifier.

(2) Losses have not been excessive for CEFLY system using coax cable. Providing coax to waveguide adapter is not a difficult problem.

s. FS/C Gain:

(1) The CEFLY power amplifier requires more drive power than is available from the FS/C under development.

(2) Univac has already obtained a fixed price quote from Sperry Microwave pertaining to the boosting of synthesizer output. The prices were included with the delivered fixed price proposal package. Sperry indicated there would be no problem in boosting power to present CEFLY levels. This change can be made at the same time that the synthesizer is being modified to 1 MHz step output capability. No schedule impact is expected.

t. Receiver Changes:

(1) The following changes are required in the Univac receiver for use in AIDATS:

(a) Remove bit synchronizer

(b) Remove demodulator

(c) Change IF frequency and bandwidth

(2) Univac intends to make the above changes to current CEFLY receivers. The signal drive level can be established by varying gain of IF amplifier. It is proposed that the X7 multiplier by incorporated in the synthesizer as is done for CEFLY. The synthesizer price quoted to ECOM already includes this feature. Univac proposes that the majority of environmental qualifications be achieved by similarity since the receiver chassis, mixer preamplifier, AGC circuitry, track error circuitry, RF switches, BITE circuitry, power supplies, etc. will remain the same. Generally the mechanical configuration will remain unchanged. The receiver basically, with exception of AGC and track error circuitry, becomes a simple down converter. (The above described comments about the receiver apply to the AIDATS/CEFLY integrated approach only.)

COMPARISON OF AIDATS AND CEFLY LANCER WBDL SPECIFICATIONS AND REQUIREMENTS

The following charts list the significant parameters of each system and the differences in performance of those equipments which have been discussed previously as being candidates for immediate incorporation into the AIDATS system.

COMPARISON OF AIDATS AND CEFLY SYSTEM SPECIFICATIONS & REQUIREMENTS

	CEFLY	AIDATS
SYSTEM		
ALTITUDE/AIRBORNE	30,000 FT	25,000 FT
RANGE	1km-250km	1km-150km
OPERATE TIME	3 MIN	5 MIN
RF POWER	150 WATTS	150 WATTS
AIRCRAFT MANEUVERS		
PITCH (Both pitch & roll)	+30° DATA TRANSFER	10°
ROLL	±45° TRACK	28°
DATA RATE	.3, 3.5, 7.0 M bits/sec	36 M bits/sec
RF BANDWIDTH	1.8, 5.0, 10.0 MHz	36 MHz (1 dB)
REMOTE GROUND ANTENNA CONTROL	1320 FT +	250 FT
LINK MARGIN @ 150NM	33.4 dB	16.7 dB
ACQUISITION SIGNAL TO NOISE RATIO	4.0 dB	9.6 dB
REACQUISITION	0-60 SEC	0-70 SEC
NAVIGATION SYSTEM	AN/ASN 86	AN/ASN 86
ECM SUSCEPTIBILITY		
AIRBORNE	10° DIRECTIONAL HORN	20° OMNI
GROUND	.8° DISH	.7° DISH
AUTOMATIC TRACK	YES	YES
AUTOMATIC SIDE LOBE REJECTION	YES	NO
MANUAL TRACK	YES	YES
MTBF		
SIMPLEX	240 hours	NOT AVAIL.
DUPLEX	141 hours	NOT AVAIL.
MODULATION	BPSK	QPSK
TRACKING ANTENNA		
DISH SIZE	6 FT	7 FT
WIND LOADING (OPERATE)	70 KNOTS (80 MPH)	40 MPH
GUSTS (NON-OPERATE)	105 KNOTS (120 MPH)	100 MPH
ICE LOADING	2 IN (9.0 LB/FT^2)	4.5 LB/FT^2
TRACKING TECHNIQUE	CONICAL SCAN	MONOPULSE
TRACKING RATE		
AZIMUTH	30 DEG/SEC	30 DEG/SEC
ELEVATION	30 DEG/SEC	18 DEG/SEC
ACCELERATION	30 DEG/SEC^2	10 DEG/SEC^2 (AZ-EL)
TRACKING ACCURACY	0.1 DEG	0.15 DEG
ANTENNA AZIMUTH ROTATION	CONTINUOUS CW OR CCW	+360°
MINIMUM GAIN	46.0 dB[1]	44 dB[1]
POLARIZATION	RH CIRCULAR	VERTICAL LINEAR
BEAMWIDTH	0.8 DEG	0.69 DEG + .20
SIDELOBES	-20 dB minimum	-16 dB minimum
FRONT-TO-BACK RATIO	35 dB minimum	NOT SPECIFIED
MTBF	16,114 hours	3100 hours minimum
STOWING TECHNIQUE	FOLDING	LOCKING

NOTES: (1) CEFLY specified at back of dish feed. AIDATS at output port. CEFLY measured gain was 44 dB minimum at output port over entire CEFLY 850 MHz bandwidth.

COMPARISON (cont.)

	CEFLY	AIDATS
FREQUENCY SYNTHESIZER		
FREQUENCY RANGE	850 MHz	650 MHz
TUNING	1 MHz STEP	10 MHz STEPS
OUTPUT POWER	15 dBm minimum	-10 dBm ± 3 dBm
CHANNELS	TRANSMIT & RECEIVER	TRANSMIT OR RECEIVE
TYPE TUNING	THUMBWHEEL (OPTIONALLY REMOTED)	REMOTE THUMB-WHEEL
RECEIVER		
NOISE FIGURE	8.0 dB	7.5 dB
SENSITIVITY		
UPLINK	-89.4 dBm(2)	NO SPECIFICATION
DOWNLINK	-85 dBm(2)	AVAILABLE
BANDWIDTH	1.9 MHz, 5 MHz, 10 MHz	36 MHz
DYNAMIC RANGE	MIN SENS TO -17 dBm	NO SPEC AVAIL-ABLE
SIDELOBE REJECTION	YES	NO
POWER AMPLIFIER		
WEIGHT	61 LBS	70 LBS
MINIMUM GAIN	50 dB	65 dB
GAIN VARIATION	$\pm$ 0.5 dB(3)	$\pm$ 0.5 dB
NOISE FIGURE	35 dB	35 dB
GROUP DELAY	1.5 NSEC(4)	1.5 NSEC
MINIMUM RF OUTPUT	150 W(5)	150 W
WARM UP TIME	3 MIN	5 MIN
SPURIOUS OUTPUT	-60 dB	-40 dB
TYPE COOLING	SELF-CONTAINED BLOWER HEAT SINK	COLD PLATE RAM AIR
PROTECTION		
HIGH VOLTAGE	YES	YES
PRIME POWER	YES	YES
RF SHORT	YES	YES
THERMAL	YES	YES
OUTPUT RF POWER SELECTION		
HIGH	YES	YES
LOW	YES	NO
RF POWER METER	YES	NO
LOW RF POWER BITE ALARM	YES	YES
STAND BY/OPERATE	YES	YES

NOTES:
(2) Data transfer sensitivity measured 3 dB greater than specification at 10^{-6} Bit Error Rate. Acquisition track sensitivity approximately 10 dB better than data transfer.
(3) Gain variation not specified for CEFLY operation. Equipment meets ± 0.5 dB.
(4) Group Delay is substituted for phase non-linearity as is allowed by Northrop power amplifier specification.
(5) CEFLY specs call for 125 watts. Equipment meets 150 watt minimum power requirements of AIDATS spec.

CONCLUSIONS

It is concluded that the CEFLY LANCER power amplifier, ground antenna system and receiver could be incorporated into the present AIDATS system without imparement of the quality of performance of the AIDATS imagery or system characteristics. The approach would lend itself to future increase in commonality and improvement in performance with the use of the 2-axis horn antennas on the aircraft, etc. However, with the imposition of the restraint of no delay in the start of limited production from the present schedule of November 1976, this approach appears to be unrealistic. The alternative then is to prove out CEFLY LANCER wide band data link components in an AIDATS configuration. This course of action will result in a commonality design which can be produced for all future AIDATS needs after the initial limited production of 9 airborne and 6 ground equipments. A commonality design, providing a proven design for AIDATS, CEFLY LANCER, and other requirements, could be produced in time to meet all future production schedules. The commonality approach would not be limited to the restraint of this study of minimum disruption to the present AIDATS procurement and could include the use of all CEFLY LANCER equipments which may be applicable to the AIDATS and other programs. In this case, the CEFLY LANCER 2-axis horns, transmitter/modulator, circularly polarized omni directional antenna, duplexers, trailer installation, etc. could be considered.

References

1. 17 Sep 75, letter from TRADOC, ATCD-SC-I, "Department of the Army Approved Required Operational Capability (ROC) for the Mohawk Data Transmission System - SLAR (MODATS-SLAR).

2. 23 Oct 75, Memo for Chief, Systems Technical Area, "Performance of the AIDATS System, by J. Bartow.

3. ECOM Research and Development Technical Report, ECOM-4386, "Prediction of the Effects of Weather on K-Band Air-to-Ground Data Link Transmission" January 1976.